Motor-Operated Valves Executive Summary

This report provides the performance evaluation based on industry experience during the 1987 through 1998 period for motor-operated valves (MOVs) in the pressurized water reactor (PWR) and in the boiling water reactor (BWR) risk- important (RI) systems. The objectives of component performance studies are (1) to determine the reliability of risk-important components and compare the results with estimates in probabilistic risk assessments (PRAs) developed to support the individual plant examinations (IPEs) and (2) to review the operational data from an engineering perspective to determine trends and patterns, and gain insights into component performance.

MOV failure and estimated demand data were obtained from two databases. The Nuclear Plant Reliability Data System (NPRDS) provided data on component failures and surveillance test frequencies for the 1987–1995 period. The Sequence Coding and Search System (SCSS) provided engineering safety features (ESF) failure and demand data for the 1987–1998 period and some surveillance test failure data for the 1987–1995 period reported in Licensee Event Reports (LERs).

For the PWR and BWR RI systems, the MOV estimated probabilities of failure on demand distributions were consistent with the generic value range from NUREG/CR-4550 (used as an input to NUREG-1150). Table ES-A lists the MOV probability of failure on demand estimates developed for the RI systems selected for this study and the NUREG/CR-4550 values. Table ES-B gives the standby failure rates for each system.

TABLE ES-A
MOV PROBABILITY OF FAILURE ON DEMAND (1987–1998)

	LOWER BOUND	MEAN	UPPER BOUND
NUREG/CR-4550	**1.1E-3**	**3E-3**	**1.1E-2**
PWR RI Systems			
auxiliary feedwater (AFW)	3.1E-4	2.1E-3	5.1E-3
high pressure injection (HPI)	1.9E-3	2.6E-3	3.4E-3
residual heat removal (RHR)	1.6E-4	1.5E-3	4.0E-3
chemical and volume control system (CVCS)	9.5E-5	2.3E-3	7.0E-3
containment spray (CS)	9.4E-4	5.5E-3	1.3E-2
reactor coolant system (RCS)	1.0E-4	2.6E-3	7.9E-3
BWR RI Systems			
high pressure coolant injection (HPCI)	5.4E-4	5.3E-3	1.4E-2
reactor core isolation cooling (RCIC)	1.7E-3	2.4E-3	3.2E-3
residual heat removal (RHR)	1.1E-3	1.5E-3	1.9E-3
low pressure core spray (LPCS)	2.3E-4	1.2E-3	2.9E-3
containment spray (CS)	1.1E-4	1.8E-3	5.3E-3
high pressure core spray (HPCS)	9.6E-4	2.6E-3	4.9E-3

TABLE ES-B
MOV STANDBY FAILURE RATE (1987–1998)

	LOWER BOUND(λ_L)	MEAN MEAN(λ)	UPPER BOUND(λ_U)
PWR RI Systems			
auxiliary feedwater (AFW)	8.1E-7/hour	1.1E-6/hour	1.4E-6/hour
high pressure injection (HPI)	7.8E-7/hour	1.0E-6/hour	1.4E-6/hour
residual heat removal (RHR)	5.2E-7/hour	6.7E-7/hour	7.7E-7/hour
chemical and volume control system (CVCS)	3.8E-7/hour	6.6E-7/hour	1.1E-6/hour
containment spray (CS)	1.5E-6/hour	2.1E-6/hour	2.8E-6/hour
reactor coolant system (RCS)	6.7E-7/hour	1.2E-6/hour	2.1E-6/hour
BWR RI Systems			
high pressure coolant injection (HPCI)	2.5E-6/hour	3.2E-6/hour	4.2E-6/hour
reactor core isolation cooling (RCIC)	9.1E-7/hour	1.3E-6/hour	1.8E-6/hour
residual heat removal (RHR)	6.2E-7/hour	8.3E-7/hour	1.1E-6/hour
low pressure core spray (LPCS)	4.1E-7/hour	6.9E-7/hour	1.1E-6/hour
containment spray (CS)	3.1E-7/hour	6.0E-7/hour	1.0E-6/hour
high pressure core spray (HPCS)	4.5E-7/hour	1.3E-6/hour	3.0E-6/hour

The yearly trend analysis of the MOV probability of failure on demand showed no statistically significant trends for the PWR AFW, HPI, and RHR systems or for the BWR RCIC and RHR systems. Statistically significant trends (decreasing) were identified for the PWR CVCS, RCS, and CS systems and for the BWR HPCI, HPCS, CS, and LPCS systems. The data for these downward trends was examined to determine the appropriate value to use for the probability of failure on demand and identified that the majority of the decrease occurred in the first three years. An examination of the last six years identified no statistically significant trends. Therefore, the mean value over the 1987–1998 period was used.

The MOV mean probabilities of failure on demand used in plant-specific IPE studies were compared with the results of this study. PWR and BWR IPE mean values were generally consistent with the results of this study and NUREG/CR-4550 generic values.

The number of complete MOV common-cause failures (CCF) identified in this study was consistent with the expected number based on the CCF database parameters for the combined PWR and BWR complete failure population used in this study.

The number of failures in PWR and BWR RI systems during the 1987-1995 period showed statistically significant decreasing trends. Both the Maintenance Rule and voluntary industry joint owners group (JOG) initiatives were begun during the period. While there was insufficient information available to conclude whether these initiatives caused the trend, an improvement had occurred.

For both PWRs and BWRs, an analysis of failure rates, as a function of component-years, did not show evidence of an increase for any plant age groups (three groups of approximately equal size, from older to newer plants by commercial operation date) due to aging mechanisms.

The motor-operator subcomponent was the biggest contributor (approximately 90%) to MOV failures in both PWRs and BWRs. For PWR motor-operators, torque switches (30%) were the predominant subcomponent part that failed; while for BWR motor-operators, motor internals (28%) were the predominant part that failed.

For reported failures, failure causes of MOV assemblies in PWR and BWR RI systems were mainly due to maintenance/procedural deficiencies, age/wear, and unknown causes.